

## REMARKS

Claims 11-30 remain in the case. The amendment to the Specification updates the status of the applications listed in the specified paragraph. Also, the application number previously inserted for one of the applications mentioned in the amended paragraph was incorrect; this typographical error is now corrected.

Several Attachments are referred to in this Response. All of these Attachments accompany the present Response.

Claims 11-20 are directed to processes for producing an aqueous biocidal compositions. In the claimed processes, an alkali metal sulfamate solution is formed from water, sulfamic acid, and alkali metal base. Bromine chloride is then added to the alkali metal sulfamate solution, while maintaining the solution at a pH of about 13.0 or greater. Claims 21-30 are directed to compositions that can be formed by the processes of Claims 11-20.

Points made in the Office Action regarding anticipation and obviousness are interspersed throughout the present Office Action. In the following, these points have been separated. Those where the disclosure of the reference and present claims are described as "not different", "the same as", or "essentially the same as" have been interpreted as applying to the anticipation rejection. Those where combinations of references are employed and where the present claims are described as obvious have been interpreted as applying to the obviousness rejection. If Applicants' interpretation of the Examiner's arguments (as to whether they apply to anticipation or obviousness) is erroneous, Applicants respectfully request an opportunity to respond to correctly categorized arguments from the Examiner, preferably in the context of a Response to a non-final Office Action.

### **Rejection under §102(b) over Goodenough**

Claims 11-30 stand rejected under 35 U.S.C. §102(b) as anticipated by Goodenough (U.S. 3,558,503).

To address this rejection, the Examiner's points regarding anticipation of the present claims by the reference are set forth, and then Applicants' arguments as to the novelty of the present claims thereafter are presented. Some of the Examiner's points were reiterated in the Office Action; for simplicity, only one passage is cited.

The Examiner makes the following arguments to support the anticipation rejection:

- Goodenough discloses that the molar ratio of bromine [Br<sub>2</sub>] to nitrogen is from about 2 to about 0.5 (Office Action, Page 2, last two lines).
- Goodenough teaches solutions made by a process comprising providing an aqueous solution of bromine and contacting therewith a bromine value stabilizer (e.g., sulfamic acid) and an effective amount of magnesium hydroxide sufficient to achieve a final pH in the system ranging from about 8 to about 10 (Office Action, Page 2, lines 15-19).
- Instant Claims 11 and 21 state that the solution's pH is about 13 or greater. Note that the pH of the aqueous alkali sulfamate solution in Goodenough's Example 3 would be about 13.9 (Exhibit 1001). (Office Action, Page 4, lines 3-5).
- If the magnesium hydroxide is replaced by an alkali hydroxide, which Goodenough encourages, the pH would actually be about 13.9 (Office Action, Page 12, lines 1-3).
- The Examiner argues that Goodenough produces BrCl from the combination of calcium chloride or sodium chloride with bromine. Based on this teaching there is no need to substitute the BrCl for Br [*sic*, Br<sub>2</sub>] in Goodenough since Goodenough's process produces BrCl (Office Action, Page 5, lines 16-19).
- The BrCl produced from the combination [of calcium chloride or sodium chloride with bromine] reacts with sulfamate or sulfamic acid to yield N-chlorosulfamate (chlorine based biocide) and N-bromosulfamate (bromine based biocide) (Office Action, Page 6, lines 6-8).
- The instant claims do not recite that the instant composition comprises N-chlorosulfamate. BrCl serves as a bromine source to produce bromosulfamate not chlorosulfamate (Office Action, Page 11, lines 3-5).
- Assuming that some difference results by practicing the process recited in instant product claims, instant specification has not shown that this difference in the preparation process

results in a product of claim 11 and 21 being different from Goodenough's product (Office Action, Page 3, lines 18-21).

It is Applicants' position that the present claims are novel over the cited reference. The following arguments demonstrate the differences of the present claims and Goodenough.

Claims 11-30 require the pH to be higher than taught in Goodenough throughout the process. As the Examiner has observed, Goodenough teaches pH values of 8 to 10 for the final solution (column 2, line 46). Since the present claims require a pH of about 13 or greater throughout the process, the claims are novel over Goodenough for at least this reason.

The Examiner has suggested that the pH of the solutions prepared in Example 3 of Goodenough would be about 13.9 if the solutions had been alkali metal sulfamate solutions rather than having been prepared with magnesium hydroxide, as described in a Goodenough. To prepare both Solution A and Solution B (of Goodenough's Example 3), Goodenough used  $\text{Mg}(\text{OH})_2$  as the base. In the Declaration of McKinnie (Exhibit 1001, Pages 38-39), the base contemplated was NaOH, not  $\text{Mg}(\text{OH})_2$ . It is emphasized that the information reported in McKinnie is **calculated**, and not based on experimental results. Also germane is that McKinnie's calculations showed that to achieve a final solution pH of 8 or 10, the initial pH of the solution would be 13.86 to 13.89, based on the amount of hydroxide needed to do achieve the desired final pH value (Exhibit 1019, Attachment 1). These calculations of McKinnie do not show maintenance of a pH of about 13 or higher during the addition of  $\text{Br}_2$ .

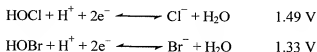
The preparation of Solution B from Goodenough's Example 3 has been repeated, both as described in Goodenough with  $\text{Mg}(\text{OH})_2$ , and by replacing the  $\text{Mg}(\text{OH})_2$  with an equimolar amount (based on hydroxide) of NaOH. In these experiments, a final pH of 13 or greater was not attained with either hydroxide. The pH of the solution prepared with  $\text{Mg}(\text{OH})_2$  was 8.75, while the solution prepared with NaOH had a pH of 11.55. Thus, Goodenough does not show solutions having a pH of about 13 or greater, regardless of whether the hydroxide is  $\text{Mg}(\text{OH})_2$  or an alkali metal hydroxide (Declaration of Nalepa, paragraph 6, Table 1; Attachment 2).

We now address now to the issue of whether or not BrCl is produced in Goodenough. As the Examiner recognizes, for N-chlorosulfamate to form in a bromine-containing alkali solution, chloride would first have to be oxidized to hypochlorite by bromine or hypobromite. Applicants submit that it is improbable that BrCl is produced from a combination of chloride (whether from NaCl or CaCl<sub>2</sub>) and Br<sub>2</sub>. For discussion purposes, Applicants point to Harp, D.L., *Current Technology of Chlorine Analysis for Water and Wastewater*, Hach Technical Information Series – Booklet No. 17 (2002), a portion of which accompanied the previous Response as Appendix D. In Harp, the following reaction is reported:



In the above equation, the Br<sup>-</sup> is formally in the -1 oxidation state, while the Br in HOBr is formally in the +1 oxidation state. Harp states that "this reaction is irreversible" (Page 12, column 2, lines 18-22). This observation is relevant because the Examiner has proposed that the reverse of this reaction occurs in the solutions of Goodenough that contain calcium chloride or sodium chloride in the presence of bromine (e.g., Example 1 of Goodenough).

Another way of looking at the feasibility of the reverse of the above reaction, in which HOBr (or OBr<sup>-</sup>) would oxidize chloride ions (Cl<sup>-</sup>) to hypochlorite ions (OCl<sup>-</sup>), is via standard reduction potentials (referred to a standard hydrogen electrode) of the respective half reactions. As a standard chemistry textbook (Boikess & Edelson, *Chemical Principles*, 3rd ed., New York: Harper & Row, 1985, page 663; Attachment 3) instructs, a greater (more positive) value of  $\epsilon^\circ$  indicates a greater tendency for the half reaction to proceed from left to right. The relevant half reactions for the above equation (as reductions) and the respective  $\epsilon^\circ$  (potential) values for each half reaction are shown below:



The potentials for these half reactions were obtained from the *CRC Handbook of Chemistry and Physics*, 63rd ed., 1982 (Page D-162; Attachment 4). Since the reduction of the chlorine species has a more positive  $\epsilon^\circ$ , it is more favored than the reduction of the bromine species. Thus the formation of oxidized chlorine species via reaction of chloride (Cl<sup>-</sup>) with Br<sub>2</sub> or

HOBr is unfavored. Therefore, it is very unlikely that any BrCl is produced inherently in the chloride-containing solutions of Goodenough.

If BrCl were produced by the combination of calcium chloride or sodium chloride with bromine in Goodenough, N-chlorosulfamate could be produced from such inherently-produced BrCl. However, since the process of Goodenough does *not* produce BrCl, no N-chlorosulfamate is formed in Goodenough.

For the sake of argument, in the unlikely event that BrCl is produced in Goodenough, the quantities thereof appear to be undetectable, and therefore the extent of N-chlorosulfamate formation would be negligible, especially in comparison to the amount of N-chlorosulfamate observed in solutions formed in accordance with the present claims. In this connection, an experiment was performed in which HOCl and Br<sup>-</sup> were brought together. The reaction proceeded quickly to completion, as monitored by UV absorbance. Since the products of the reaction were HOBr and Cl<sup>-</sup>, the starting materials for the postulated formation of BrCl in the solutions of Goodenough, any formation of HOCl therefrom would have been detected in the UV spectra as an increase in the peak for HOCl. No such increase was observed (Declaration of Nalepa, Figure 1).

As described in paragraphs 6-7 of the Second Declaration of McKinnie (Exhibit 1073, attached as Appendix A to the previous Response), an aqueous biocidal solution formed in accordance with the present claims has about 80 mole% N-bromosulfamate and about 20 mole% N-chlorosulfamate, consistent with bromine chloride being an equilibrium mixture of 20 mole% Br<sub>2</sub>, 20 mole% Cl<sub>2</sub>, and 60 mole% BrCl. In contrast, any N-chlorosulfamate produced by the postulated oxidation of Cl<sup>-</sup> to OCl<sup>-</sup> would result in much less than 20 mole% N-chlorosulfamate relative to the amount of bromine used.

The Examiner is correct regarding the recitation of N-chlorosulfamate in the present claims; the N-chlorosulfamate is produced inherently. As detailed in the Second Declaration of McKinnie, solutions according to the present claims were prepared and tested (paragraphs 4-5). In his Second Declaration, McKinnie observes that the results of the DPD tests are the same regardless of the preparation method for the BrCl - preformed or made inline (*i.e.*,

immediately prior to addition; paragraph 6). Thus, the N-chlorosulfamate is always present in the solutions of the instant claims.

The Examiner's further argument, that bromine chloride does not form N-chlorosulfamate, is disproved by the results presented in McKinnie's Second Declaration.

Whether an invention is novel depends on what is recited in the *claims*, not what is disclosed in the Specification, since the claims will be rejected. As stated in 37 C.F.R. §1.104(c)(1):

If the invention is not considered patentable, or not considered patentable as claimed, the claims, or those considered unpatentable will be rejected.

Applicants submit that there is commentary in the M.P.E.P. that can be misinterpreted to indicate that the Specification may or should show differences, see §2141.02, part IV:

Applicants who allege they discovered the source of a problem must provide evidence substantiating the allegation, either by way of affidavits or declarations, or by way of a clear and persuasive assertion in the specification (citing *In re Wiseman*, 596 F.2d 1019, 201 U.S.P.Q. 658 (CCPA 1979)).

In other words, as long as the evidence is part of the record, it is acceptable; the Specification is one acceptable form of evidence in the record. In the present case, the Declarations of McKinnie and the newly-submitted Declaration of Nalepa constitute evidence in the record which supports the patentability of the present claims.

Furthermore, as described above, the Declaration of McKinnie and the Declaration of Nalepa demonstrate that the final pH in Goodenough's Example 3 is well below 13. In addition, the Second Declaration of McKinnie shows that a solution made with bromine chloride produces a characteristic relative amount of N-chlorosulfamate, which characteristic relative amount is not shown in Goodenough, either explicitly or inherently.

It should be clear from the foregoing that the present claims are novel over Goodenough. The present claims require BrCl, not Br<sub>2</sub>; Goodenough does not teach a pH of 13 or greater; N-chlorosulfamate, if any is produced in Goodenough, is not present in a characteristic relative ratio to N-bromosulfamate. Thus, Applicants respectfully request reconsideration and withdrawal of the rejection under 35 U.S.C. §102(b).

**Rejection under §103(a) over Goodenough in view of several references**

Claims 11-30 stand rejected under 35 U.S.C. §103(a) as obvious over Goodenough (U.S. 3,558,503) in view of:

Declaration of B. Gary McKinnie (Exhibit 1001);

Second Declaration of B. Gary McKinnie, 2/14/05 (Exhibit 1073);

Mills et al., Bromine Chloride: an Alternative to Bromine, *Ind. Eng. Chem. Prod. Res. Develop.*, vol. 12, No. 3, 1973, pp. 161160-165 (Exhibit 2014);

Declaration of Dr. Jack Mills, 12/6/04 (Exhibit 2021);

Expert Declaration of Dr. Shunong Yang, 12/6/04 (Exhibit 2022); and

Expert Declaration of John A. Wojtowicz, 12/7/04 (Exhibit 2023),

where the Exhibit numbers refer to Interference No. 105,230, which interference involved the instant application.

To address this rejection, the Examiner's points regarding obviousness of the present claims by the reference are set forth, and then Applicants' arguments as to the nonobviousness of the present claims thereover are presented. Some of the Examiner's points were reiterated in the Office Action; for simplicity, only one passage is cited.

The Examiner makes the following arguments to support the obviousness rejection:

- The subject matter of the instant claims recites an active bromine content of "at least about 100,000 ppm and an atomic ratio of nitrogen to active bromine of greater than 0.93" would have been obvious to a person having ordinary skill in the art because the prior art ranges and instantly claimed ranges overlap (Office Action, Page 9, line 21, to Page 10, line 2).
- Goodenough encourages the use of alkali hydroxides (Office Action, Page 11, last line, to Page 12, first line).
- The Examiner argues that Goodenough produces BrCl from the combination of calcium chloride or sodium chloride with bromine. Based on this teaching there is no need to substitute the BrCl for Br [*sic*, Br<sub>2</sub>] in Goodenough since Goodenough process produces BrCl (Office Action, Page 12, lines 8-11).

- The BrCl produced from the combination reacts with sulfamate or sulfamic acid to yield N-chlorosulfamate (chlorine based biocide) and N-bromosulfamate (bromine based biocide) (Office Action, Page 12, lines 20-22).
- The Examiner argues that the pH of the aqueous alkali sulfamate solution in Goodenough's Example 3 would be at a pH of about 13.9 (Exhibit 1001) based on the combination of chemicals. Goodenough's pH of around 13.9 makes obvious the instantly claimed pH of about 13 or greater. It would have been obvious to one having ordinary skill in the art at the time of the filing of the instant case to provide an initial solution as set forth in instantly claimed subject matter having a pH between 13 and 14, which encompasses the claimed range, in order to maintain the storage stability of the final product (Office Action, Page 4, lines 5-10).
- According to Jack F. Mills & John A. Schneider, "Bromine Chloride: an Alternative to Bromine," 12 *Ind. Eng. Chem. Prod. Res. Develop.* 160-165, no. 3 (1973) (Exhibit 2014; "Mills paper"), bromine chloride and bromine are interchangeable brominating agents and the former offers, inter alia, important cost and ecological advantages. (Mills paper at 160). (Office Action, Page 8, last two lines, to Page 9, line 3).
- Goodenough discloses that the order of combining ingredients is not critical and that Example 3 in Goodenough closely resembles the claimed order of combining the ingredients. Absent a showing of the criticality of the order of combining ingredients, Goodenough makes obvious the instant order of combining ingredients (Office Action, Page 6, lines 9-13).
- The Examiner argues that when it is suggested that the prior art, in case the Goodenough patent, gives the same product and process as claimed, unexpected results assist in overcoming the prior art (Office Action, Page 9, lines 16-20), and that Applicants have not shown unexpected results for BrCl in comparison to bromine (Office Action, Page 11, lines 2-3).

It is Applicants' position that the present claims are nonobvious over the cited references, and the following arguments underscore the nonobviousness of the present claims.



The ranges in the present claims for the active bromine content (at least about 100,000 ppm) and the atomic ratio of nitrogen to active bromine (greater than 0.93) are stated to be obvious because the prior art ranges and instantly claimed ranges overlap. However, the active bromine content and the atomic ratio of nitrogen to active bromine are not the only distinguishing features of the present claims. The claims as a whole must be considered, , not just the ranges by themselves, as required by 35 U.S.C. §103. As stated by the Federal Circuit in *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561, 1 U.S.P.Q.2d 1593, 1595-96 (Fed. Cir.), *cert. denied*, 481 U.S. 1052 (1987):

In making the assessment of differences, section 103 specifically requires consideration of the claimed invention "as a whole." Inventions typically are new combinations of existing principles or features...The "as a whole" instruction in title 35 prevents evaluation of the invention part by part. Without this important requirement, an obviousness assessment might break an invention into its component parts (A + B+ C), then find a prior art reference containing A, another containing B, and another containing C, and on that basis alone declare the invention obvious. Section 103 precludes this hindsight discounting of the value of new combinations by requiring assessment of the invention as a whole.

It is submitted that focusing on the active bromine content and the atomic ratio of nitrogen to active bromine alone ignores the requirement for considering the claims as a whole, and the active bromine content and the atomic ratio of nitrogen to active bromine are not enough to form or sustain an obviousness rejection of the present claims. Other features of the claims must also be considered. The claimed invention is directed to BrCl, an order of addition, and certain pH values, in addition to the active bromine content and the atomic ratio of nitrogen to active bromine.

The Examiner has argued that Goodenough produces BrCl from the combination of calcium chloride or sodium chloride with bromine, so that there is no need to substitute the BrCl for Br<sub>2</sub> since Goodenough's process produces BrCl. As discussed above, Goodenough does not produce BrCl in the solutions containing calcium chloride or sodium chloride and bromine. Because Goodenough does not teach the formation of BrCl, there is nothing in Goodenough that would have made the use of bromine chloride obvious.

As described above regarding the anticipation rejection, Goodenough does not disclose a pH of around 13.9, nor does Goodenough teach or suggest maintaining a pH as

high as 13 during formation of the solutions therein. In fact, Goodenough teaches a final pH from about 8 to about 10.

The Examiner notes that the opinions of Drs. Yang and Wojtowicz in their respective Declarations (Exhibits 2022 and 2023) do not directly address the issue of whether it would have been obvious to add bromine or bromine chloride to an alkali metal sulfamate which is maintained at pH 13.0 or greater (Office Action, Page 5, lines 2-5). The Examiner states that

Drs. Yang and Wojtowicz both favor that it would have been obvious to one having ordinary skill in the art at the time of the filing of instant to provide an initial solution as set forth in instantly claimed subject matter having a pH between 13 and 14, which encompasses the claimed range, in order to maintain the storage stability of the final product. (Office Action, Page 9, lines 16-20.)

What Drs. Yang and Wojtowicz actually state is that it would have been obvious to provide an initial solution as set forth in Count 1 having a pH of at least 7 (Exhibits 2022 and 2023, paragraph 88 in each). Neither Declaration singles out a pH of about 13 or greater.

To support the obviousness rejection, the Examiner cites Mills et al. to show that bromine chloride and bromine are interchangeable brominating agents and that BrCl offers important cost and ecological advantages (Mills paper at 160). Applicants submit that there are differences between bromine chloride and bromine (*i.e.*, they are not so interchangeable), and that whether BrCl or Br<sub>2</sub> has the advantage can depend on the desired purpose for the reagent. Mills et al. states that bromine chloride reacts faster than bromine; the significantly faster reaction speeds observed with bromine chloride may indicate that a particular reaction is harder to control than it would be if bromine were used instead. Another important difference between Br<sub>2</sub> and BrCl is evidenced by their physical properties. As can be seen from the respective freezing and boiling points in Table I of Mills et al., Br<sub>2</sub> is a liquid between -7°C and 59°C, while BrCl is a liquid between -65°C and 5°C. Thus, under ambient conditions, BrCl is a gas, which may not be desirable, since BrCl gas is corrosive, and thus requires care and skill in its handling and use (Specification, Page 2, lines 1-6).

As the Examiner recognizes, Goodenough discloses that the order of combining ingredients is not critical. However, Goodenough also states that better results are obtained by adding hydroxide **last** (column 2, lines 12-15; column 5, lines 9-15). In the present

claims, the need for an alkali metal sulfamate (made from sulfamate acid and an alkali metal base) and a pH of 13 or greater throughout the process (including initially), necessitates adding at least a portion of the alkali metal base (hydroxide) **prior to** last in the process. Further, Goodenough also teaches that the stabilizer can be added after the bromine is added (column 2, lines 41-46). In other words, Goodenough teaches several orders of addition, and prefers one that is contrary to the requirements of the present claims.

In this connection, the repeated preparation of Solution B from Goodenough's Example 3, and the analogous preparation with NaOH, as described in the Declaration of Nalepa, provided interesting results. In particular, the stability (as measured by activity in ppm Br<sub>2</sub>) is markedly lower for solution made with sodium hydroxide. After four days, the solution prepared with NaOH retained only 69% of its original activity, while the solution prepared with Mg(OH)<sub>2</sub> as in Goodenough retained 97% of its original activity (Declaration of Nalepa, paragraph 9, Table 2). Thus, the teachings of Goodenough indicate that alkali metal bases provide solutions which are inferior for retention of activity. This indicates that the presently claimed solutions do provide unexpected results – significantly higher retention of activity (99% after 4 days) while using an alkali metal base; see the Declaration of Nalepa, Table 2.

Another indicator of unexpected results is hinted at by Mills et al., which states that  
Concern about side reactions such as chlorination may also have been a factor, since BrCl exists in an equilibrium mixture containing molecular chlorine and bromine. However, recent studies using liquid BrCl have made such problems no longer a major concern. (Page 160, last 5 lines.)

This suggests that all of the active species produced from BrCl are bromine-containing species. Based on this statement of Mills et al., the finding that the N-chlorosulfamate species in the solutions of the instant claims are present at 20 mole%, while the N-bromosulfamate species are present at 80 mole%, is unexpected.

In view of the foregoing, Applicants respectfully request reconsideration and withdrawal of the rejection under 35 U.S.C. §103(a).

**Acknowledgement of submitted IDSes**

Applicants have not received acknowledgement that the Examiner has considered the Information Disclosure Statement submitted on May 9, 2003. It is hereby requested that the Examiner forward such acknowledgement Applicants at his earliest convenience.

In light of the foregoing, the application is submitted to be in condition for allowance. Thus, favorable action on the claims in the case is respectfully requested.

If matters remain requiring further consideration, the Examiner is respectfully requested to telephone the undersigned so that such matters may be discussed and, if possible, can be promptly resolved.

Respectfully submitted,  
/Mary H. Drabnis/

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# APPENDIX B (Exhibit 1019)

Br2/N = 2.0

	Br2	sulfamic NaOH	Water
MMW/g/mole	159.82	97.09	18.015
grams	100.00	30.37	832.08
moles	0.6257	0.3129	0.8368
d (g/cm3)	3.102	2.150	0.987
vol (ml)	32.23	14.13	17.89
molar ratio	2.0000	1.0000	3.0003
moles OH prior to Br2 addition:		0.6258	
vol. of solution (L) prior to Br2 addition:		0.8666	
[OH-] prior to Br2 addition:		0.7221	
total vol (L) after Br2 addition:		0.8668	
pH prior to Bromine addition:		13.86	

Br2/N = 1.0

	Br2	sulfamic NaOH	Water
MMW/g/mole	159.82	97.09	18.015
grams	100.00	60.75	789.19
moles	0.6257	0.6257	1.2515
d (g/cm3)	3.10	2.15	2.10
vol (ml)	32.23	28.28	23.84
molar ratio	1.0000	1.0000	2.0001
moles OH prior to Br2 addition:		0.6258	
vol. of solution (L) prior to Br2 addition:		0.8437	
[OH-] prior to Br2 addition:		0.7418	
total vol (L) after Br2 addition:		0.8759	
pH prior to Bromine addition:		13.87	

## NOTES:

1. In order to achieve a final pH of 10 you need an excess hydroxide concentration (mol/L) = 0.0001
2. The final solution mass was set at 1000 g with an active bromine content of 100,000 ppm (i.e., 10% W/W). Accordingly, 100 g of bromine reactant is necessary (assuming 100% yield).
3. The weight of sulfamic acid was calculated based on the Br2/N ratio selected.
4. The weight of NaOH was calculated based on the moles needed to neutralize the H+ generated by sulfamic acid and HBr, added to the moles required to achieve the final pH.
5. The total volume of solution was estimated as the sum of the volumes of the individual reactants based on

Attachment 1

MOORE EXHIBIT  
1019

published densities.

Br<sub>2</sub>/N = 2.0 Final pH=8.0

Br <sub>2</sub>	sulfamic NaOH	Water
159.82	97.09	40
grams	100.00	30.37
moles	0.6257	0.9866
d (g/cm <sup>3</sup> )	3.102	2.150
vol (ml)	32.23	14.13
molar ratio	2.0000	1.0000

moles OH prior to Br<sub>2</sub> addition: 0.6257  
 vol. of solution (L) prior to Br<sub>2</sub> addition: 0.8886  
 [OH] prior to Br<sub>2</sub> addition: 0.7220  
 total vol (L) after Br<sub>2</sub> addition: 0.8988  
 pH prior to Bromine addition: 13.86

Br<sub>2</sub>/N = 1.0 Final pH=8.0

Br <sub>2</sub>	sulfamic NaOH	Water
159.82	97.09	40
grams	100.00	60.75
moles	0.6257	1.2514
d (g/cm <sup>3</sup> )	3.10	2.15
vol (ml)	32.23	28.28
molar ratio	1.0000	2.0000

moles OH prior to Br<sub>2</sub> addition: 0.6257  
 vol. of solution (L) prior to Br<sub>2</sub> addition: 0.8437  
 [OH] prior to Br<sub>2</sub> addition: 0.7417  
 total vol (L) after Br<sub>2</sub> addition: 0.8759  
 pH prior to Bromine addition: 13.87

# NOTES:

1. In order to achieve a final pH of 8 you need an excess hydroxide concentration (mol/L) = 0.000001

2. The final solution mass was set at 1000 g with an active bromine content of 100,000 ppm (i.e., 10% w/w). Accordingly, 100 g of bromine reactant is necessary (assuming 100% yield).

3. The weight of sulfamic acid was calculated based on the Br<sub>2</sub>/N ratio selected.

4. The weight of NaOH was calculated based on the moles needed to neutralize the H<sup>+</sup> generated by sulfamic acid and HBr, added to the moles required to achieve the final pH.

5. The total volume of solution was estimated as the sum of the volumes of the individual reactants based on published densities.

Br<sub>2</sub>/N = 5 Final pH=8.0

Br <sub>2</sub>	sulfamic NaOH	Water
159.82	97.09	40
grams	100.00	75.08
moles	0.6257	1.2514
d (g/cm <sup>3</sup> )	3.102	2.150
vol (ml)	32.23	56.51
molar ratio	1.0000	2.0000

moles OH prior to Br<sub>2</sub> addition: 0.6257  
 vol. of solution (L) prior to Br<sub>2</sub> addition: 0.7978  
 [OH] prior to Br<sub>2</sub> addition: 0.7843  
 total vol (L) after Br<sub>2</sub> addition: 0.8300  
 pH prior to Bromine addition: 13.89

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

ROBERT M. MOORE JR., ET AL. )

APPLN. NO.: 09/785,890 )

GROUP ART UNIT: 1616 )

CONFIRMATION NO.: 5058 )

FILED: FEBRUARY 16, 2001 )

EXAMINER: ALTON N. PRYOR )

CONTINUOUS PROCESSES FOR  
PREPARING CONCENTRATED  
AQUEOUS LIQUID BIOCIDAL  
COMPOSITIONS )

Customer No.: 65895 )

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Sir:

DECLARATION UNDER 37 C.F.R. §1.132

Christopher J. Nalepa, Ph.D., hereby declares as follows:

1. I am a chemist employed by Albemarle Corporation, the assignee of the above-identified application by recorded assignment.
2. In 1980, I received the degree of Ph.D. in chemistry from Rice University.
3. Since 1980, I have been continuously employed as a chemist by Albemarle Corporation and the predecessor thereof, Ethyl Corporation, at the research laboratory facilities in Baton Rouge, Louisiana.
4. I am an Applicant in the above-identified application.
5. The test work described herein was conducted by me at the Albemarle Process Development Center in Baton Rouge, Louisiana.
6. In the first part of this work, Solution B of Example 3 of Goodenough (U.S. 3,558,503) was repeated, with magnesium hydroxide as described in Goodenough, and by substituting the  $Mg(OH)_2$  with an equivalent amount of NaOH.

6. The order of addition of the reagents for Solutions 1 and 2 and their respective amounts are listed in Table 1 below.
7. The relative amounts of Solution 3, prepared in accordance with the present claims, is also shown in Table 1.

TABLE 1

Reagent	Solution 1 Goodenough	Solution 2 Goodenough modified	Solution 3 present case
Water	485.30 g	478.95 g	223.20 g
Sulfamic Acid	6.05 g	6.05 g	58.00 g
Bromine	5.00 g	5.01 g	--
BrCl	--	--	56.75 g
Mg(OH) <sub>2</sub>	3.65 g	--	--
NaOH (50% activity)	--	10.00 g	162.08 g
Total wt. of soln.	500.00 g	500.01 g	500.03 g
Moles of OH <sup>-</sup>	0.125	0.125	2.025
pH of soln.	8.75	11.55	13.47

8. Solution 1 is cloudy and contains some solids.
9. The activities of Solutions 1 and 2 were measured initially and after storage for 4 days at 40°C. The initial activity and the activity after 4 days were also measured for a solution prepared in accordance with the present claims having the proportions shown above. The activities for all three of these solutions are shown in Table 2.

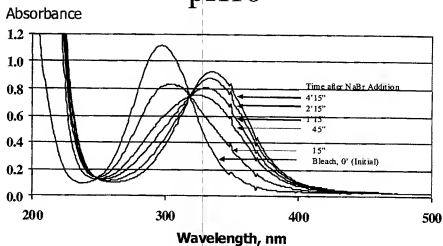
TABLE 2

Solution	Initial activity	Activity after 4 days	Activity retained
Solution 1 - Mg(OH) <sub>2</sub>	9560 ppm Br <sub>2</sub>	9290 ppm Br <sub>2</sub>	97%
Solution 2 - NaOH	9610 ppm Br <sub>2</sub>	6600 ppm Br <sub>2</sub>	69%
Solution 3 - NaOH	149,000 ppm Br <sub>2</sub>	150,000 ppm Br <sub>2</sub>	99%



10. It is my considered opinion that Goodenough does not show solutions having a pH of about 13 or greater, regardless of whether the hydroxide is  $\text{Mg}(\text{OH})_2$  or an alkali metal hydroxide, based on the above results.
11. In the second part of this work, the reaction of  $\text{HOCl}$  with  $\text{Br}^-$  to form  $\text{HOBr}$  (and  $\text{Cl}^-$ ) at pH 10 by UV absorption was studied. The absorption peaks for  $\text{HOCl}$  ( $\lambda_{\text{max}} = 292 \text{ nm}$ ) and  $\text{HOBr}$  ( $\lambda_{\text{max}} = 330 \text{ nm}$ ) were monitored.
12.  $\text{HOCl}$  and  $\text{Br}^-$  were brought together in an aqueous solution at pH 10. The  $\text{HOCl}$  was in the form of bleach;  $\text{NaBr}$  was added to the bleach solution. As seen by the UV absorbance scans taken at several time intervals, the reaction to form  $\text{HOBr}$  was complete in less than 5 minutes.
13. Figure 1 shows the UV absorbance spectra for the reaction.

## Conversion of $\text{HOCl}$ to $\text{HOBr}$ at pH10



$[\text{HOCl}] = [\text{Br}^-] = 0.00284 \text{ mol/L}$ ; 201 ppm as  $\text{Cl}_2$ ; 233 ppm  $\text{Br}^-$

FIG. 1

15. It is my considered opinion that no detectable amount of HOCl is formed from HOBr and  $\text{Cl}^-$ , based on the UV absorbance results.
16. I hereby declare that all statements made herein of my own knowledge are true and that all statement made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: August 4, 2009

  
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Christopher J. Nalepa

THIRD EDITION

# Chemical Principles

**Robert S. Boikess**

*Rutgers, The State University of New Jersey*

**Edward Edelson**

1817



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Attachment 3

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The cover illustration is a computer-generated model of a complex consisting of the enzyme carboxyl proteinase and its substrate, the drug pepstatin. The image shows a molecule of pepstatin that is bound to the active site of the enzyme. This kind of high-resolution computer model is now playing an important role in the development of drugs by enabling the design of compounds that are tailored to fit the active sites of biological molecules. Computer models also have become indispensable tools for the study of complex biological molecules such as proteins, nucleic acids, and carbohydrates.

The complex of pepstatin and proteinase was described by R. Bott, E. Subramanian, and D. Davies; the coordinates were provided by Dr. Joel Sussman and Dr. David Davies. The computer graphics were produced with the assistance of Professor R. Levy, Professor W. Olson, and Dr. J. Keepers of the biophysical chemistry group at Rutgers; the photographs were obtained by Professor P. Orenstein of the Department of Visual Arts at Rutgers. We acknowledge their kind assistance.

Chemical Principles, Third Edition

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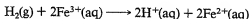
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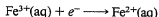
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84 85 86 87 9 8 7 6 5 4 3 2 1

for which  $\mathcal{E}^\circ = +0.770$  V with the hydrogen electrode as the anode. The cell reaction is



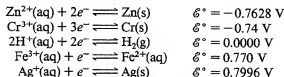
Again,  $\text{Fe}^{3+}$ , the substance in the cathode, is more easily reduced than  $\text{H}^+$ . The potential of the reduction half-reaction



is positive; it has the value of the cell potential,  $\mathcal{E}^\circ = +0.770$  V.

### The emf Series

We can continue our list of half-reactions and their standard potentials with these two electrode processes:



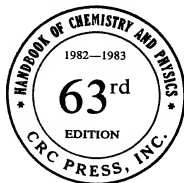
A tabulation of this kind, listing reduction half-reactions in order of increasing standard potential, is sometimes called an **emf** (electromotive force) series or an **electrochemical series**. It can be used to predict and correlate a large body of data on chemical behavior. Table 16.1 is a more comprehensive list of this kind. Let us summarize some of the conventions we have used or implied about these half-reactions and their standard potentials.

1. The potentials in this series are standard potentials, since all gases in the systems are at a pressure of 1 atm and all dissolved species are at a concentration of 1M.
2. By definition, the standard hydrogen electrode has a standard potential of zero. All other electrode potentials are measured relative to this electrode, directly or indirectly.
3. All the half-reactions in the series are written as reductions. But it is understood that when two half-reactions are coupled in a cell or in a chemical system, one will reverse and proceed as an oxidation.
4. The magnitude of the standard electrode potential is a measure of the extent to which the half-reaction proceeds from left to right. The more positive the value of  $\mathcal{E}^\circ$ , the greater the tendency of the reaction to proceed from left to right. The more negative the value of  $\mathcal{E}^\circ$ , the smaller the tendency of the reaction to proceed from left to right.
5. The potential of a half-reaction is not related to the coefficients of the equation, which means that the value of  $\mathcal{E}^\circ$  does not change if both

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In collaboration with a large number of professional chemists and physicists whose assistance is acknowledged in the list of general collaborators and in connection with the particular tables or sections involved.



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Attachment 4

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## ELECTROCHEMICAL SERIES

Table I  
Alphabetical listing  
Compiled by J. F. Hunsberger  
Values listed are Standard Reduction Potentials

Reaction	Potential, volts	Reaction	Potential, volts
$\text{Ag}^+ + e^- \rightarrow \text{Ag}$	0.7996	$\text{Ce}^{3+} + 3e^- \rightarrow \text{Ce(Hg)}$	-1.4373
$\text{Ag}^+ + e^- \rightarrow \text{Ag}^*(4\text{fHClO}_4)$	1.987	$\text{Ce}^{4+} + e^- \rightarrow \text{Ce}^{3+}$	1.4430
$\text{AgAc} + e^- \rightarrow \text{Ag} + \text{Ac}^-$	0.64		1.611
$\text{AgBr} + e^- \rightarrow \text{Ag} + \text{Br}^-$	0.0713	$\text{Ce}^{4+} + e^- \rightarrow \text{Ce}^{3+} \cdot 0.5\text{f H}_2\text{SO}_4$	1.4587
$\text{AgBrO}_3 + e^- \rightarrow \text{Ag} + \text{BrO}_3^-$	0.680	$\text{CeOH}^{3+} + \text{H}^+ + e^- \rightarrow \text{Ce}^{3+} + \text{H}_2\text{O}$	1.7134
$\text{AgClO}_4 + 2e^- \rightarrow \text{Ag} + \text{ClO}_4^-$	0.4776	$\text{Cl}_2(\text{g}) + 2e^- \rightarrow 2\text{Cl}^-$	1.3583
$\text{AgCl} + e^- \rightarrow \text{Ag} + \text{Cl}^-$	0.2223	$\text{HClO}_2 + \text{H}^+ + e^- \rightarrow 1/2\text{Cl}_2 + \text{H}_2\text{O}$	1.63
$\text{AgCN} + e^- \rightarrow \text{Ag} + \text{CN}^-$	-0.02	$\text{HClO} + \text{H}^+ + 2e^- \rightarrow \text{Cl}^- + \text{H}_2\text{O}$	1.49
$\text{Ag}_2\text{CO}_3 + 2e^- \rightarrow 2\text{Ag} + \text{CO}_3^{2-}$	-0.4769	$\text{ClO}^- + \text{H}_2\text{O} + 2e^- \rightarrow \text{Cl}^- + 2\text{OH}^-$	0.90
$\text{Ag}_2\text{CrO}_4 + 2e^- \rightarrow 2\text{Ag} + \text{CrO}_4^{2-}$	0.4663	$\text{ClO}_2 + e^- \rightarrow \text{ClO}_2^-$	1.15
$\text{Ag}_2\text{Fe(CN)}_6 + 4e^- \rightarrow 2\text{Ag} + \text{Fe(CN)}_6^{4-}$	0.1943	$\text{ClO}_2 + \text{H}^+ + e^- \rightarrow \text{HClO}_2$	1.27
$\text{AgI} + e^- \rightarrow \text{Ag} + \text{I}^-$	-0.1519	$\text{HClO}_2 + 2\text{H}^+ + 2e^- \rightarrow \text{HClO} + \text{H}_2\text{O}$	1.64
$\text{Ag}_2\text{IO}_3 + e^- \rightarrow \text{Ag} + \text{IO}_3^-$	0.3551	$\text{HClO}_2 + 3\text{H}^+ + 2e^- \rightarrow 1/2\text{Cl}_2 + \text{H}_2\text{O}$	1.63
$\text{Ag}_2\text{MoO}_4 + 2e^- \rightarrow 2\text{Ag} + \text{MoO}_4^{2-}$	0.49	$\text{HClO}_2 + 3\text{H}^+ + 4e^- \rightarrow \text{Cl}^- + 2\text{H}_2\text{O}$	1.56
$\text{AgNO}_3 + e^- \rightarrow \text{Ag} + \text{NO}_3^-$	0.59	$\text{ClO}_2 + \text{H}_2\text{O} + 2e^- \rightarrow \text{HClO} + 2\text{OH}^-$	0.59
$\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2e^- \rightarrow 2\text{Ag} + 2\text{OH}^-$	0.342	$\text{ClO}_2 + 2\text{H}_2\text{O} + 4e^- \rightarrow \text{Cl}^- + 4\text{OH}^-$	0.76
$\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2e^- \rightarrow 2\text{Ag} + 2\text{OH}^-$	0.74	$\text{ClO}_2(\text{aq}) + e^- \rightarrow \text{ClO}_2^-$	0.954
$\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2e^- \rightarrow 2\text{Ag} + 2\text{OH}^-$	0.599	$\text{ClO}_2 + 2\text{H}^+ + e^- \rightarrow \text{ClO}_2 + \text{H}_2\text{O}$	1.15
$\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2e^- \rightarrow 2\text{Ag} + 2\text{OH}^-$	0.41	$\text{ClO}_2 + 3\text{H}^+ + 2e^- \rightarrow \text{HClO}_2 + \text{H}_2\text{O}$	1.21
$\text{Ag}_2\text{O} + \text{H}_2\text{O} + 2e^- \rightarrow 2\text{Ag} + 2\text{OH}^-$	-0.7051		
$\text{Ag}_2\text{S} + 2\text{H}^+ + 2e^- \rightarrow 2\text{Ag} + \text{H}_2\text{S}$	-0.0366	$\text{ClO}_2 + 6\text{H}^+ + 5e^- \rightarrow \text{ICl}_3 + 3\text{H}_2\text{O}$	1.47
$\text{Ag}_2\text{SCN} + e^- \rightarrow \text{Ag} + \text{SCN}^-$	0.8993	$\text{ClO}_2 + 6\text{H}^+ + 6e^- \rightarrow \text{Cl}^- + 3\text{H}_2\text{O}$	1.45
$\text{Ag}_2\text{SeO}_3 + 2e^- \rightarrow 2\text{Ag} + \text{SeO}_3^{2-}$	0.829	$\text{ClO}_2 + \text{H}_2\text{O} + 2e^- \rightarrow \text{ClO}_2^- + 2\text{OH}^-$	0.35
$\text{Ag}_2\text{SO}_4 + 2e^- \rightarrow 2\text{Ag} + \text{SO}_4^{2-}$	0.653	$\text{ClO}_2 + 3\text{H}_2\text{O} + 2e^- \rightarrow \text{Cl}^- + 3\text{H}_2\text{O}$	0.62
$\text{Ag}_2\text{WO}_4 + 2e^- \rightarrow 2\text{Ag} + \text{WO}_4^{2-}$	0.466	$\text{ClO}_2 + 2\text{H}^+ + 2e^- \rightarrow \text{ClO}_2 + \text{H}_2\text{O}$	1.19
$\text{Al}^{3+} + 3e^- \rightarrow \text{Al} \text{ (0.1f NaOH)}$	-1.706	$\text{ClO}_2 + 8\text{H}^+ + 7e^- \rightarrow \text{ICl}_3 + 4\text{H}_2\text{O}$	1.34
$\text{Al}(\text{OH})_3 + \text{H}_2\text{O} + 3e^- \rightarrow \text{Al} + 4\text{OH}^-$	-2.35	$\text{ClO}_2 + 8\text{H}^+ + 8e^- \rightarrow \text{Cl}^- + 4\text{H}_2\text{O}$	1.37
$\text{As} + 3\text{H}^+ + 3e^- \rightarrow \text{As(H)}$	-0.54	$\text{ClO}_2 + \text{H}_2\text{O} + 2e^- \rightarrow \text{HClO}_2 + 2\text{OH}^-$	0.17
$\text{As}_2\text{O}_3 + 6\text{H}^+ + 6e^- \rightarrow 2\text{As} + 3\text{H}_2\text{O}$	0.234	$\text{ClO}_2 + 3\text{H}^+ + 2e^- \rightarrow 2\text{HClO} + \text{H}_2\text{O}$	0.37
$\text{As}_2\text{O}_3 + 3\text{H}^+ + 3e^- \rightarrow \text{As}_2\text{O}_3 + \text{H}_2\text{O}$	0.2475	$2\text{HCNO} + 2\text{H}^+ + 2e^- \rightarrow (\text{CN})_2 + \text{H}_2\text{O}$	0.33
$\text{AsO}_2^- + 2\text{H}_2\text{O} + 3e^- \rightarrow \text{As} + 4\text{OH}^-$	-0.68	$(\text{CN})_3\text{C}^- + 2e^- \rightarrow 2\text{CN}^-$	0.77
$\text{H}_2\text{AsO}_4 + 2\text{H}^+ + 2e^- \rightarrow \text{HAsO}_4 + \text{H}_2\text{O} \text{ (if HCl)}$	0.58	$\text{Co}^{3+} + e^- \rightarrow \text{Co}^{2+} \text{ (f HNO}_3\text{)}$	1.842
$\text{AsO}_2^- + 2\text{H}_2\text{O} + 3e^- \rightarrow \text{As} + 4\text{OH}^-$	-0.71	$\text{Co}^{3+} + e^- \rightarrow \text{Co}^{2+} \text{ (f HNO}_3\text{)}$	1.842
$\text{AsO}_2^- + 2\text{H}_2\text{O} + 3e^- \rightarrow \text{AsO}_2^- + 4\text{OH}^- \text{ (if NaOH)}$	-0.08	$\text{Co}^{3+} + 2\text{H}^+ + 2e^- \rightarrow \text{HCOOH}$	-0.2
$\text{Au}^{3+} + 3e^- \rightarrow \text{Au}$	1.68	$\text{Co}^{3+} + 2\text{H}^+ + 2e^- \rightarrow \text{H}_2\text{CO}_3$	-0.49
$\text{Au}^{3+} + 2\text{H}_2\text{O} + 3e^- \rightarrow \text{Au} + 4\text{OH}^-$	1.29	$\text{Co}(\text{NH}_3)_6^{3+} + e^- \rightarrow \text{Co}(\text{NH}_3)_6^{2+}$	0.1
$\text{Au}^{3+} + 2\text{H}_2\text{O} + 3e^- \rightarrow \text{Au} + 4\text{OH}^-$	1.42	$\text{Co}(\text{OH})_2 + 2e^- \rightarrow \text{Co} + 2\text{OH}^-$	-0.73
$\text{AuBr}_3 + e^- \rightarrow \text{Au} + 3\text{Br}^-$	0.963	$\text{Co}(\text{OH})_2 + e^- \rightarrow \text{Co}(\text{OH})_2 + \text{OH}^-$	0.2 (0.17)
$\text{AuBr}_3 + 3e^- \rightarrow \text{Au} + 3\text{Br}^-$	0.858	$\text{Cr}^{3+} + 2e^- \rightarrow \text{Cr}^{2+}$	-0.537
$\text{AuCl}_3 + 3e^- \rightarrow \text{Au} + 3\text{Cl}^-$	0.994	$\text{Cr}^{3+} + e^- \rightarrow \text{Cr}^{2+}$	-0.41
$\text{Au}(\text{OH})_3 + 3\text{H}^+ + 3e^- \rightarrow \text{Au} + 3\text{H}_2\text{O}$	1.45	$\text{Cr}^{3+} + 3e^- \rightarrow \text{Cr}$	-0.73
$\text{H}_2\text{BO}_3 + 5\text{H}_2\text{O} + 8e^- \rightarrow \text{B(H)}_3 + 8\text{OH}^-$	-1.24	$\text{Cr}^{3+} + 3e^- \rightarrow \text{Cr}^{0} \text{ (f H}_2\text{SO}_4\text{)}$	1.10
$\text{H}_2\text{BO}_3 + 5\text{H}_2\text{O} + 8e^- \rightarrow \text{B} + 4\text{OH}^-$	-3.25	$\text{Cr}^{3+} + 3e^- \rightarrow \text{Cr}^{0} \text{ (f NaOH)}$	-0.12
$\text{H}_2\text{BO}_3 + 3\text{H}^+ + 3e^- \rightarrow \text{B} + 3\text{H}_2\text{O}$	-0.73	$\text{Cr}^{3+} + e^- \rightarrow \text{Cr}^{2+} \text{ (f H}_2\text{SO}_4\text{)}$	-0.0034
$\text{Ba}^{2+} + 2e^- \rightarrow \text{Ba}$	-2.90	$\text{CrO}_2 + 2\text{H}_2\text{O} + 3e^- \rightarrow \text{Cr} + 4\text{OH}^-$	-1.2
$\text{Ba}^{2+} + 2e^- \rightarrow \text{Ba(Hg)}$	-1.570	$\text{HCrO}_2 + 7\text{H}^+ + 3e^- \rightarrow \text{Cr}^{3+} + 4\text{H}_2\text{O}$	-1.195
$\text{Ba}(\text{OH})_2 + \text{H}_2\text{O} + 2e^- \rightarrow \text{Ba} + 2\text{OH}^- + \text{H}_2\text{O}$	-2.97	$\text{CrO}_2 + 4\text{H}_2\text{O} + 3e^- \rightarrow \text{Cr(OH)}_3 + 5\text{OH}^-$	-0.12
$\text{Ba}^{2+} + 2e^- \rightarrow \text{Ba}$	-1.70	$(\text{CrOH})_3 + 3e^- \rightarrow \text{Cr} + 3\text{OH}^-$	-1.3
	(-1.851)	$\text{Cu}^+ + e^- \rightarrow \text{Cu}$	-2.923
$\text{Br}_2\text{O}_3 + 3\text{H}_2\text{O} + 6e^- \rightarrow 2\text{Br}^- + 6\text{OH}^-$	-2.28	$\text{Cu}^+ + 2\text{CN}^- + e^- \rightarrow \text{Cu(CN)}_2$	0.522
$\text{BrCl}_2 + 3e^- \rightarrow \text{Br}^- + 4\text{Cl}^-$	0.168	$\text{Cu}^{2+} + e^- \rightarrow \text{Cu}^+$	0.118
$\text{Br}_2\text{O}_3 + 3\text{H}_2\text{O} + 6e^- \rightarrow 2\text{Br}^- + 6\text{OH}^-$	-0.46	$\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$	0.167
$\text{Br}_2\text{O}_3 + 4\text{H}^+ + 2e^- \rightarrow \text{Br}_2 + 2\text{H}_2\text{O}$	1.59	$\text{Cu}^{2+} + e^- \rightarrow \text{Cu} + 2\text{H}^+$	0.00
$\text{BrO}^- + 2\text{H}^+ + 3e^- \rightarrow \text{Br}^- + \text{H}_2\text{O}$	0.32	$\text{Cu}_2\text{O} + \text{H}_2\text{O} + 3e^- \rightarrow 2\text{Cu} + 3\text{OH}^-$	-0.561
$\text{BrOCl} + 3\text{H}_2\text{O} + 3e^- \rightarrow \text{Br}^- + \text{Cl}^- + \text{H}_2\text{O}$	0.1583	$\text{Cu(OH)}_2 + 2e^- \rightarrow \text{Cu} + 2\text{OH}^-$	-0.224
$\text{BrOCl} + \text{H}_2\text{O} + 3e^- \rightarrow \text{Br}^- + \text{H}_2\text{O}$	-0.46	$2\text{Cu(OH)}_2 + 2e^- \rightarrow \text{Cu}_2\text{O} + 2\text{OH}^- + \text{H}_2\text{O}$	-0.69
$\text{Br}_2 + 2e^- \rightarrow 2\text{Br}^-$	1.087	$\text{Cu}^{2+} + e^- \rightarrow \text{Cu}^+$	-0.1004
$\text{Br}_2(\text{l}) + 2e^- \rightarrow 2\text{Br}^-$	1.065	$2\text{O}^{2-} + 2e^- \rightarrow \text{O}_2$	-0.444
$\text{HBrO} + \text{H}^+ + e^- \rightarrow 1/2\text{Br}_2 + \text{H}_2\text{O}$	1.59	$\text{Eu}^{3+} + e^- \rightarrow \text{Eu}^{2+}$	-0.04
$\text{HBrO} + \text{H}^+ + 2e^- \rightarrow \text{Br}^- + \text{H}_2\text{O}$	1.33	$1/2\text{F}_2 + e^- \rightarrow \text{F}^-$	2.85
$2\text{HBrO} + 2\text{H}^+ + 2e^- \rightarrow \text{Br}_2(\text{l}) + 2\text{H}_2\text{O}$	1.6	$1/2\text{F}_2 + \text{H}^+ + e^- \rightarrow \text{HF}$	3.03
$\text{BrO}^- + \text{H}_2\text{O} + 2e^- \rightarrow \text{Br}^- + 2\text{OH}^- \text{ (if NaOH)}$	0.70	$\text{Fe} + 2e^- \rightarrow \text{Fe}^{2-}$	2.87
$\text{BrO}_2^- + 6\text{H}^+ + 5e^- \rightarrow 1/2\text{Br}_2 + 3\text{H}_2\text{O}$	1.62	$\text{C}_2\text{F}_6 + 2\text{H}^+ + 4e^- \rightarrow \text{H}_2\text{O} + 2\text{F}^-$	-0.4402
$\text{BrO}_2^- + 6\text{H}^+ + 6e^- \rightarrow \text{Br}^- + 3\text{H}_2\text{O}$	1.44	$\text{Fe}^{3+} + 2e^- \rightarrow \text{Fe}$	-0.036
$\text{BrO}_2^- + 3\text{H}_2\text{O} + 6e^- \rightarrow \text{Br}^- + 4\text{OH}^-$	0.61	$\text{Fe}^{3+} + 3e^- \rightarrow \text{Fe}$	0.770
$\text{C}_2\text{F}_6 + 2\text{H}^+ + 3e^- \rightarrow \text{C}_2\text{F}_4 + \text{H}_2\text{O}$	0.6992	$\text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+} \text{ (if HCl)}$	0.770
$\text{Ca}^{2+} + 2e^- \rightarrow \text{Ca}$	-3.02	$\text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+} \text{ (if HClO}_4\text{)}$	0.747
$\text{Ca}^{2+} + 2e^- \rightarrow \text{Ca}$	-2.76	$\text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+} \text{ (if H}_2\text{PO}_4\text{)}$	0.438
$\text{Calomel Electrode, Molar KCl}$	0.2800	$\text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+} \text{ (0.5f H}_2\text{SO}_4\text{)}$	0.679
$\text{Calomel Electrode, N KCl}$	0.2807	$\text{Fe(CN)}_6^{4-} + e^- \rightarrow \text{Fe(CN)}_6^{3-} \text{ (0.01f NaOH)}$	0.46
$\text{Calomel Electrode, 0.1 N KCl}$	0.3337	$\text{Fe(CN)}_6^{4-} + e^- \rightarrow \text{Fe(CN)}_6^{3-} \text{ (if H}_2\text{SO}_4\text{)}$	0.49
$\text{Calomel Electrode, Sat'd KCl}$	0.2415	$\text{FeO}_2^{2-} + 8\text{H}^+ + 3e^- \rightarrow \text{Fe}^{3+} + 4\text{H}_2\text{O}$	1.9
$\text{Calomel Electrode, Sat'd NaCl}$	0.2360	$\text{Fe(OH)}_3 + e^- \rightarrow \text{Fe(OH)}_2 + \text{OH}^-$	-0.56
$\text{Ca(OH)}_2 + 2e^- \rightarrow \text{Ca} + 2\text{OH}^-$	-3.02	$\text{Fe (phenanthroline)}_2^{2+} + e^- \rightarrow \text{Fe(phen)}_2^+$	1.44
	-0.4026	$\text{Fe (phenanthroline)}_2^{2+} + e^- \rightarrow \text{Fe(phen)}_2^+ \text{ (f H}_2\text{SO}_4\text{)}$	1.056
$\text{Cd}^{2+} + 2e^- \rightarrow \text{Cd}$	-0.4026		-0.560
$\text{Cd}^{2+} + 2e^- \rightarrow \text{Cd(Hg)}$	-0.761		
$\text{Cd(OH)}_2 + 2e^- \rightarrow \text{Cd(Hg)} + 2\text{OH}^-$	(-0.81)		
$\text{CdSO}_4 \cdot 8/3\text{H}_2\text{O} + 2e^- \rightarrow \text{Cd(Hg)} + \text{CdSO}_4 \text{ (sat'd aq)}$	-0.4366		
$\text{Ce}^{3+} + 3e^- \rightarrow \text{Ce}$	-2.335		
		$\text{H}_2\text{GaO}_4 + \text{H}_2\text{O} + 3e^- \rightarrow \text{Ga} + 4\text{OH}^-$	-1.22